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EMG Analysis of Latissimus Dorsi, Erector Spinae and Middle Trapezius Muscle Activity during Spinal Rotation: A Pilot Study

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EMG ANALYSIS OF LATISSIMUS DORSI, ERECTOR SPINAE AND MIDDLE
TRAPEZIUS MUSCLE ACTIVITY DURING SPINAL ROTATION: A PILOT STUDY

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Bachelor of Science in Physical Education, Exercise Science and Wellness
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For the degree of

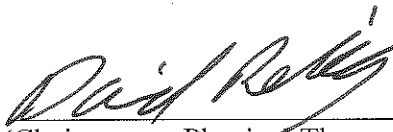
Doctor of Physical Therapy

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This Scholarly Project, submitted by Jamie Flint, Toni Linneman, Rachel Pederson, and Megan Storstad in partial fulfillment of the requirements for the Degree of Doctor of Physical Therapy from the University of North Dakota, has been read by the Advisor and Chairperson of Physical Therapy under whom the work has been done and is hereby approved.


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Department Physical Therapy

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10/16/15

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ABSTRACT

Purpose/Hypothesis: Rotation of the spine, a complex movement that has yet to be fully understood, occurs regularly in activities of daily living (ADLs) and sport performance. Rotation (twisting) of the spine is a contributing factor in low back pain pathology and, by reports, has been associated with up to 60% of all back injuries. One of the largest muscles of the back, the latissimus dorsi (LD), is the only muscle to attach to the spine, pelvis, ribs, scapula, and humerus, and has the potential to impact the spine during many different activities. To date, there is limited research on the activity of the LD during spinal rotation or the effects of the muscle in rehabilitation programs for patients with low back pain (LBP). The purpose of this pilot study was to determine the LD muscle activity throughout spinal rotation during open and closed kinetic chain activities. Three hypotheses were established.

Materials/Methods: Muscle activity of the LD was recorded by surface electrodes while the subjects performed rotation to the left and right in standing and in quadruped positions. Spinal rotation motion was initiated in the four test positions (standing rotation right/left, quadruped rotation right/left) by movement of the pelvis. Muscle activity was normalized to the maximal voluntary contraction (MVC) of the muscle. Significance was set at $\alpha=.05$ level.

Results: The ipsilateral LD muscle produced significantly more muscle activity during spinal rotation while in fixed (quadruped) than the contralateral LD muscle ($p < .05$). In a right fixed position, or left spinal rotation, the ipsilateral LD was significantly more active than the MT and ES ($p < .001$). However, in the left fixed position, or right spinal rotation, the ipsilateral LD was not significantly more active than the MT and ES ($p = .156$). In the non-fixed positions, the LD was not significantly more active, and in fact, the ES was significantly more active than the LD and MT in 3 of the 4 testing positions ($p < .001$).

Discussion/Conclusion: The results of this study found the LD to be more active during the fixed positional movements. In the right fixed position, the left LD had significantly higher EMG activity than the MT and ES. However, this was not found to be true in the left fixed position. The data showed a significant difference between the activation of the right and left LD, which could be examined further in the future. Although the LD are active without the arms fixed, they demonstrate a significantly greater muscle activity when placed in a quadruped position. When in standing without the upper extremities fixed, other muscles have a greater function in rotation of the spine.

Clinical Relevance: This pilot study highlights the contributions of the LD muscle with spinal rotation and is the beginning of ongoing research efforts to address LD as part of the rotational movement strategy in individuals both with and without LBP. Many everyday movements require spinal rotation with the UEs fixed. Frequently, rehabilitation for LBP includes positions such as the quadruped position. LD is a muscle that should be considered when looking at spinal rotational movement systems.

CHAPTER I

INTRODUCTION

Low back pain is a disabling condition that is highly prevalent in today's society, affecting about two-thirds of people in the United States at some point in their life. It is also the second most common reason for visiting a physician.¹ This condition has economically taken a toll on the health care system, with estimated direct medical costs totaling \$34 billion in 2010.² Accompanying the direct costs of back pain is the impact of the condition on an individual's ability to function. Approximately 23 percent of patients with low back pain classify their level of pain as disabling.³ One of the leading risk factors associated with low back pain in the United States is lifting, often occurring in an occupational setting. An estimated 30 percent of workers in the United States lift in a harmful manner. Spinal rotation occurs in most of these lifting tasks and is associated with 60 percent of low back injuries.⁴ Once an injury occurs, physicians often refer patients to physical therapy for management of this diagnosis.

Current physical therapy management for low back pain includes exercise protocols targeting the transversus abdominis, quadratus lumborum, oblique abdominals, multifidus, erector spinae, diaphragm, and pelvic floor muscles.⁵ While these muscles do have an impact in the treatment of low back pain, the latissimus dorsi has the potential to play a large role in stabilizing the spine of the lower back region. Therefore, in cases of low back pain where the stability of the low back is compromised, the inclusion of latissimus dorsi in physical therapy interventions needs to be considered.

Problem Statement

To date, the research concerning the activation of the latissimus dorsi has mainly focused on its contribution to upper extremity movement. While the latissimus dorsi plays a key role in upper extremity function, it also has the potential to have a significant effect on the spine. Literature commonly describes the erector spinae musculature as the primary agonists in spine rotation, with its attachments to the spinous processes and its close proximity to the spine. However, the latissimus dorsi also has attachments to the spinous processes and therefore has the potential to impact spinal rotation. Without proper identification of the latissimus dorsi's contribution to spine rotation, proper rehabilitation of a patient with a spinal pathology would be impossible.

Scope of Study

The latissimus dorsi has proximal attachments on the spinous processes of the T7 to L5 vertebrae, as well as on the iliac crest, sacrum, thoracolumbar fascia, inferior angle of the scapula and the lower three or four ribs. The distal attachment is on the floor of the intertubercular groove of the humerus. The primary actions typically associated with the latissimus dorsi include shoulder adduction, medial rotation, and extension. Since the latissimus dorsi muscle attaches to spinous processes, its involvement in spinal rotation is a concept that should be better understood.

Purpose of Study

The purpose of this study was to determine the level of muscle activity of several back muscles including latissimus dorsi (LD), middle trapezius (MT), and erector spinae (ES) with spinal rotation in positions with and without fixation of the upper extremities. The conclusions drawn from this study will assist practicing clinicians with the

development of better exercise programs for their clients with back or upper extremity pathology.

Significance of the Study

The significance of this study to the field of physical therapy is to gain a better understanding of the role of the LD during spinal rotation. Muscular imbalances can cause excessive strain and stress on anatomical structures, which can result in low back pain. Physical therapy intervention primarily focuses on improvement of these muscle imbalances. This study will also provide physical therapists and physical therapy students with better knowledge of the kinetics of spinal rotation. Further research may be stimulated to look further into muscle activation of patients with low back pain.

Research Questions

- 1.) Is the LD significantly more active with upper extremities fixed or not fixed?
- 2.) Is the LD significantly more active than the ipsilateral MT and ES during spinal rotation with the upper extremities fixed?
- 3.) Is the LD significantly more active than the ipsilateral MT and ES during spinal rotation with the upper extremities not fixed?

Null Hypothesis

- 1.) There is no significant difference in EMG activity (% MVC) of the LD between the fixed and non-fixed positions.
- 2.) There is no significant difference in the activation of the LD compared to the ipsilateral and ES during spinal rotation when the upper extremities are fixed.

- 3.) There is no significant difference in the activation of the LD compared to the ipsilateral MT and ES during spinal rotation when the upper extremities are not fixed.

Alternative Hypothesis

- 1.) There is a significant difference in EMG activity (% MVC) of the LD between the fixed and non-fixed positions.
- 2.) There is a significant difference in the activation of the LD compared to the ipsilateral MT and ES during spinal rotation when the upper extremities are fixed.
- 3.) There is a significant difference in the activation of the LD compared to the ipsilateral MT and ES during spinal rotation when the upper extremities are not fixed.

CHAPTER II

LITERATURE REVIEW

Physical therapists treat a large population of patients with spinal pathologies. It can often be difficult to determine the cause, due to the many muscles and ligaments that attach to the spine. A comprehensive knowledge of spinal anatomy and muscle function is crucial for proper rehabilitation of these patients.

One muscle that is often overlooked as a contributor to spinal pathology is the LD. This muscle has attachments on a vast number of spinous processes, giving it the mechanical ability to impact spinal movement, especially axial rotation. However, it is often only referred to as having an action at the upper extremity.

Very few published textbooks cite the LD as having an action on the spine. Some research studies have investigated the LD, but do not address its role on the spine.⁶⁻¹⁰ There have been research studies that investigate spinal rotation and include the LD, but they are not conclusive in its role.^{1,11-23} A study specifically relating to the latissimus dorsi in spinal rotation is needed to fully understand its role during this movement. In order to do this properly, a full review of spine anatomy and biomechanics, as well as research study development and protocol, is necessary.

Spine Anatomy

The axial skeleton consists of the cranium, spinal column, ribs, and sternum. The axial skeleton is connected to the appendicular skeleton by the sternoclavicular joints superiorly and the SI joint inferiorly.²⁴ The spinal column is divided into 7 cervical, 12

thoracic, 5 lumbar, 5 sacral vertebrae, and 4 coccygeal segments. The sacral and coccygeal segments are generally fused in adults and form a separate sacral and coccygeal bone. Each segment is abbreviated alphanumerically from superior to inferior, C1-S5. Intervertebral discs connect the vertebrae providing shock absorption and distribution of forces.²⁴

Typical vertebrae can be divided into three sections - the body, posterior arch and pedicles. The anterior portion of the vertebra is the body, which is the primary weight bearing component. Vertebral bodies get progressively larger as the column descends to support more weight. Just posterior to the body lays the vertebral canal which houses and protects the spinal cord. The posterior portion of the vertebrae consists of the transverse and spinous processes, laminae, and articular processes. The transverse and spinous processes serve as attachment sites of muscles and ligaments. The lamina forms the connection between the spinous and transverse processes while the pedicles connect the anterior and posterior elements of the vertebrae and transfer muscle forces.

Although the LD does not attach to the cervical vertebrae, they are still a crucial aspect to the biomechanics of spinal rotation. The cervical spine has the smallest and most mobile vertebrae. They allow for a wide range of motion of the head. This level has small rectangular bodies that are wider from side to side than front to back. The transverse foramina are located in the transverse processes and contain the vertebral artery which brings blood to the brain and spinal cord.

Inferior to the cervical vertebrae are the thoracic vertebrae. These have pedicles that are pointed directly posterior. Their large transverse processes project posterolateral

and each contains a costal facet that articulates with the corresponding rib. The spinous processes are angled inferiorly, overlapping with the transverse process below.

Vertebrae in the lumbar region of the spine have very wide vertebral bodies to support the weight of the upper body. The lamina and pedicles are short and thick and form the posterior walls of the vertebral canal. The transverse processes project laterally. Spinous processes are broad and rectangular and project straight posteriorly.

The most inferior portion of the spinal column is the sacrum. It consists of 5 fused vertebrae and transmits the weight of the vertebral column to the pelvis. It has a very broad superior surface to articulate with the L5 vertebrae. The triangular, sacral canal protects the cauda equina. The pedicles in this region are very thick and extend laterally. There are many connective tissues and muscles that attach to the sacrum and vertebrae for stability and movement.

The thoracolumbar fascia (TLF) is a connective tissue structure built out of aponeurotic and fascial planes that come together to surround the paraspinal muscles and stabilize the lumbosacral spine. The TLF connects the LD muscle to the spinous processes of the lumbar spine. In addition to its attachments to the lumbar spinous processes, the thoracolumbar fascia also attaches to the sacrum and ilium near the posterior superior iliac spines and covers the posterior surface of the ES muscle group. Many trunk and extremity muscles insert into this connective tissue structure and can play a role in its tension and stiffness.²⁵ With these attachments and connections to the LD and gluteus maximus musculature, the TLF provides mechanical stability to the sacroiliac joint and the low back.

The LD is the largest muscle of the back. It originates on the spinous processes of T7-12, L1-5, the thoracolumbar fascia, ribs 9-12 (interlocks with the external oblique), posterior one-third of the iliac crest and the supraspinous ligament. It inserts on the floor of the intertubercular groove of the humerus and the deep fascia of the arm. The superior muscle fibers are almost horizontal, and become more vertical as the origin moves inferior. It is innervated by C6-8 nerve roots via the thoracodorsal nerve. Its traditional actions are extension, adduction and medial rotation of the arm.^{26,27} The LD depresses the shoulder girdle indirectly, by pulling the humerus inferiorly and works as the primary medial rotator of the glenohumeral joint. It is most powerful in overhead activities including adducting a raised arm against resistance and elevation of the pelvis with arms fixed, such as climbing.²⁶ It can also be used during forced expiration in breathing.²⁸

Some studies suggest the LD laterally bends and extends the lumbar spine. It is also believed that it may have a role in rotation.^{23,27} Due to the LD's proximal muscle attachment to the lumbopelvic region and its distal attachment to the proximal humerus, it has the largest moment arm length on the spine, compared to other posterior trunk muscles.²⁸ From a human cadaver dissection study, the majority of the force-generating capability of the LD lies within the lumbopelvic region and not the thoracic region (64% vs 36%).²⁸ The large moment arm suggests that the LD muscle can influence lumbopelvic movements with less effort than other tissues. The LD is put on stretch when the upper extremities are moved into a flexed or abducted position. This results in a tensile force on the thoracolumbar fascia as the distance between the two points of attachment increases.

During bending and lifting tasks, the LD muscle functions bilaterally to extend, adduct, and internally rotate the arm, bringing the object closer to the body and also

contributes to lumbar extension.²⁴ When a person does not engage the LD during lifting tasks, the upper limbs will move passively towards an individual's trunk, resulting in decreased control of the object being lifted and causing increased strain on the spinal extensor muscles. Therefore, it is thought that the LD muscle can assist with bilateral lifting tasks by equalizing the forces on the lumbar spine. This can potentially prevent abnormal stresses on the lumbopelvic tissues.²⁸

The MT has similar muscle fiber alignment to the superior portion of the LD, therefore may also contribute to spinal rotation. The MT is part of the trapezius muscle group, which has upper, middle and lower fibers. The MT group originates on T1-5 spinous process and supraspinous ligaments. It inserts on the medial acromial margin and superior lip of the crest on the spine of the scapula. The fibers of this muscle run horizontal from origin to insertion. It is active during scapular retraction and innervated by the accessory (CN XI) nerve.²⁶

The ES muscles are divided into three groups. From lateral to medial, they are the iliocostalis, the longissimus and the spinalis. All of the ES muscles originate from a broad tendon that attaches to the posterior iliac crest, sacrum, sacroiliac ligaments, sacral and inferior lumbar spinous processes, and supraspinous ligaments. The lumborum portion of the iliocostalis muscle inserts on the angle of ribs 7-12, the thoracic portion inserts on the angle of ribs 1-6 and transverse process of C7, and the cervicis portion inserts on the transverse processes of C4-6. The thoracic portion of the longissimus inserts on the transverse process and ribs in the thoracic region, the cervicis portion inserts on the transverse processes in the cervical region, and the capitis portion inserts on the mastoid process. The thoracis and cervicis portion of the spinalis muscle inserts on the spinous

processes of the middle to upper thoracic spine and the capitis portion blends with the semispinalis capitis. This large musculotendinous mass is covered by the serratus posterior inferior and thoracodorsal fascia.^{29,30} For the purpose of this study, these muscles will be referred to as a group, or the erector spinae (ES).

The ES muscles work bilaterally by extending the trunk, neck, and head. Unilaterally, they laterally flex and rotate the trunk to the ipsilateral side. Eccentrically, they control the descent of the spine with forward bending. Isometrically, they function to stabilize the lower thorax with respect to the pelvis. The superficial muscles of the ES muscle group have a significant lever arm for rotation of the lumbar spine. Deeper muscles of the ES help to anchor the lumbar vertebrae to the ilium. Biomechanically, these muscles have a posterior direction of pull which reduces anterior shear forces that may occur between the lower lumbar vertebrae and sacrum. Other functions of the deep ES muscles in the lumbar region include the ability to increase the compressive forces and check rotary forces between vertebral segments.²⁸

The multifidus, a muscle located deep to the ES, also plays a key role in lumbopelvic movements. However, this muscle is not investigated in this study. It originates on the dorsal surface of the sacrum, aponeurosis of the ES muscle, medial surface of the posterior superior iliac spine, posterior sacroiliac ligaments and mammillary processes in the lumbar spine. From these sites, the multifidus travels superiorly and medially to its insertion sites of the spinous processes. It is much larger in the lumbopelvic region compared to the thoracic and cervical region. The functions of the muscle include spinal extension, anti-flexion, and anti-shear. Due to its attachment to the spinous processes, the multifidus also has the potential to assist with spinal rotation but

has a very poor lever arm due to the orientation of the muscle compared to the axis of rotation. Perhaps the most important function of the multifidus muscle is stabilization of the joints in the lumbar spine.²⁸

Many joints are located in the lumbopelvic region, including zygapophyseal joints, intervertebral joints, and sacroiliac joints. These structures work together to allow the body weight, frictional, and ground reaction forces to be transferred throughout the entire lumbar spine.²⁸ The intervertebral discs are important structures that help the joints distribute forces. These discs contain a viscous center portion called the nucleus pulposus, which is surrounded by a fibrous structure termed the annulus fibrosus. The annulus fibrosus functions to contain the nucleus pulposus within the intervertebral disc structure. As weight is shifted between vertebrae, the nucleus pulposus is maneuvered within the annulus fibrosus for better distribution of forces. Other structures that may have an influence on motion and force distribution in the lumbopelvic region include the ligamentum flavum, apophyseal joint capsule, and cartilaginous end plates. Consideration of the lumbar spine anatomy has a great influence on the biomechanical impact of motion in this area of the body.

Biomechanics

The thoracic spine is the most mechanically stable portion of the vertebral column due to its attachments between the vertebrae and rib cage. Intervertebral discs in this region are relatively thin and the addition of costal joints limits the extent to which one vertebral body can rotate on another before being blocked by bony compression. The articular facets of the thoracic vertebrae are generally orientated in the frontal plane. Normal range of motion values of the thoracic spine are 20-45 degrees of flexion, 25-45

degrees of extension, 20-40 degrees of lateral flexion, and 30-35 degrees of rotation.³¹

These values are presented in Table 1. Thoracic vertebrae located closer to the lumbar region begin to display different characteristics, as the articular facets begin to shift their orientation from the frontal plane towards the sagittal plane.

The lumbar spine normally exhibits 40-50 degrees of lordosis when in the standing position. The lumbar spine has the ability to move in three degrees of freedom: flexion-extension, lateral flexion, and rotation. Due to the sagittal plane orientation of the facet surfaces of the lumbar apophyseal joints, movement in the sagittal plane is greater than the coronal and horizontal planes.²⁴ Normal range of motion values in the sagittal plane are 40-60 degrees of flexion and 20-35 degrees of extension. Individuals typically display normal range of motion values of 15-20 degrees of lateral flexion.³¹ These values are also listed in Table 1. The motion in particular interest of this study is spinal rotation.

Spinal rotation in the lumbar spine is limited by the strong sagittal orientation of the apophyseal joints. These joints compress on the contralateral side with the motion and consequently block further movement. During spinal rotation, the articular cartilage is compressed to produce the rotational movement. Lumbar axial rotation is stabilized by the multifidi muscles and rigid sacroiliac joints.²⁴ The total range of motion values for spinal rotation in the lumbar spine normally equates to only 3-18 degrees and is listed in Table 1.³¹

Although it does not contribute as much motion as the thoracic and lumbar region, the sacrum has important biomechanical contributions as well. The base of the sacrum is inclined anteriorly and inferiorly to form a 40 degree angle from the superior margin of the sacrum from the horizontal plane. This is called the sacro-horizontal angle, which is

measured in the sagittal plane. Orientation of the sacrum results in an anterior shear force from the weight of the body, typically equal to 64% of the superimposed body weight.²⁴ There are several structures surrounding this area which act to resist the anterior shear force. These include the more frontal orientation of the L5-S1 facet surfaces, anterior longitudinal ligament, iliolumbar ligament, and fibers of the quadratus lumborum muscle.²⁴

Table 1. Normal Range of Motion Values of the Lumbar and Thoracic Spine³¹

Motion	Lumbar Spine (in degrees)	Thoracic Spine (in degrees)
Flexion	40-60	20-45
Extension	20-35	25-45
Lateral Flexion	15-20	20-40
Rotation	3-18	35-50

Surface Electromyography

Surface electromyography (SEMG) is a safe, easy and noninvasive way to measure the energy production of a muscle. Every time a muscle contracts, it gives off an action potential. The source of the SEMG signal comes from the action potentials of motor units located in a muscle. When more motor units are recruited, more action potentials are elicited that cause an increased external force exerted by a particular muscle. The sum of the action potentials is picked up by the electrodes and amplified by the SEMG instrument to produce the volume conducted signal. Surface electromyography is not a measure of force, strength, amount of effort given or of muscle resting length. The SEMG output is the measure of electrical activity produced by the muscle under inspection. In order to compare different muscles using SEMG, a maximal voluntary contraction (MVC) is performed first, and then comparisons are done as

percentage of MVC. The MVC for each muscle is completed in the standard manual muscle testing (MMT) position.²⁷

Optimal electrode placement will reduce the amount of interference, or cross-talk, from other muscles in the area. Electrode placement should be where there is a minimum amount of tissue between the electrodes and the fibers of the selected muscle. Whenever possible, the electrodes should be aligned parallel to the fibers to maximize sensitivity and selectivity.²⁷ The placement should be consistent and easily found with anatomical landmarks to ensure accuracy. For the LD, the electrodes are placed over the muscle belly at the T12 level and along a line connecting the most superior point of the posterior axillary fold and the S2 spinous process.^{12-14,20} The MT electrodes are placed 4 cm lateral to the spinous process of T3.³² The ES electrodes are horizontally aligned with the L3-4 interspace, 4 cm lateral to midline.^{1,7,11,16-19} A ground electrode is placed over the spinous process of T7, which is an easily identifiable bony landmark that will not obstruct movement or signal conduction.

Skin impedance is the resistance of the skin to direct current.²⁷ This can be affected by the moisture of the skin, the superficial skin oil content, hair, adipose tissue, and the density of the horny, dead-cell layer.²⁷ It is important for skin impedance to be as low as possible and balanced between the two recording electrodes to provide optimal signal. For research purposes, the impedance at the electrode site should be less than 10,000 Ohms.²⁷ This is accomplished by shaving, if necessary, abrading with fine grit sandpaper and cleaning the skin with alcohol. A conduction medium should also be used on adhesive electrodes, which often come pregelled. After the electrodes are properly applied, maximal voluntary contractions for each muscle can be performed.

Maximal Voluntary Contraction

The maximal voluntary contraction (MVC) is the maximum amount of force a muscle can produce during testing. The International Society of Electrophysiology and Kinesiology (ISEK) has developed standards for documenting MVC. In order to get the most accurate reading, the subject should be given some preliminary training and practice. Without training, the MVC could be as much as 20-30% less than that obtained after appropriate training and lead to incorrect conclusions or interpretations of data (ISEK). It has been demonstrated that verbal encouragement could enhance the performance during MVC, therefore including visual feedback and/or verbal encouragement is discouraged during the maximal contraction for data consistency.^{1,33-35}

There is some controversy on the best position to find a MVC of the LD. Oftentimes, the MVC is performed in the standard MMT position. However, it has been found that prone upper extremity extension results in more activation of the LD than all other positions tested.³⁶ This position produced a MVC of 92.62% which is significant for the inclusion of this testing position in our study.³⁶

The MVC position for the MT is prone lying with the subject's shoulder at the edge of the table, which is the standard MMT position. The shoulder is abducted to 90 degrees and the elbow is flexed at a right angle. Stabilization is provided on the contralateral scapula. Resistance is placed over the distal end of the humerus and is directed downward toward the floor.²⁶

The MVC testing position for the ES is performed in the standard MMT position. The participant is placed in a prone position with hands at sides. Stabilization is provided at the pelvis and ankles. The participant extends the lumbar spine until the entire trunk is

raised from the table (clears umbilicus). No external resistance is applied during this test.²⁶

Muscle Function

It is important to understand the different ways muscles function, specifically in the low back region. This can help determine the forces provided on the spine during movement, and providing information on how to eliminate any unwanted forces to this area. It also provides information on how to strengthen muscles in this region, such as the LD.

There are three types of contractions a muscle can produce. An isometric contraction occurs when a muscle is producing a force while maintaining a constant position. A concentric contraction occurs when a muscle is shortening against a force and the distal segment is moving towards the proximal segment. An eccentric contraction occurs when a muscle is lengthening against a force and the distal segment moves away from the proximal segment.

All muscles function in open and closed kinetic chain movements. An open kinetic chain movement would occur when the distal segment of a kinetic chain is not fixed to the earth or other immovable object. A closed kinetic chain movement would occur when the distal segment of a kinetic chain is fixed to the earth or other immovable object. In the lower extremity, for example, kicking a ball would be an open chain movement and squatting would be a closed chain movement.²⁴ For this study, open chain movements were compared to closed chain movements.

Testing Positions

All muscles, including the LD, function in open and closed chain positions, which influence the way they perform. The distal portion of the LD is the upper extremity, and the proximal portion of the chain is the trunk. For a closed chain position, the upper extremities need to be fixed and the trunk needs to be free to move. A way to isolate this movement would be lifting the leg in the quadruped position, therefore rotating the trunk. In this study, the movements are defined as “right fixed position” and “left fixed position”.

Right Fixed Position: In the quadruped position (weight bearing through one’s hands and knees), the subject elevates his/her right knee off the surface so that the thigh remains perpendicular to the plane of the surface. This action results in the anatomical movement of left spinal rotation initiated by the pelvis.

Left Fixed Position: In the quadruped position, the subject elevates his/her left knee off the surface so that the left knee remains perpendicular to the plane of the surface. This action results in the anatomical movement of right spinal rotation initiated by the pelvis.

For an open chain position, the trunk needs to be fixed and the upper extremities are free. This can be accomplished with standing spinal rotation. Terms to define these movements are “right non-fixed position” and “left non-fixed spinal position”.

Right Non-Fixed Position: In a standing position, with the subject’s feet placed shoulder-width apart and arms crossed, the subject initiates left spinal rotation by moving the right side of the pelvis posteriorly in the horizontal plane. The subject’s feet and shoulders remain in a fixed position during this movement.

Left Non-Fixed Position: In the standing position with the subject's feet placed shoulder-width apart and arms crossed, the subject initiates right spinal rotation by moving the left side of the pelvis posteriorly in the horizontal plane. The subject's feet and shoulders remain in a fixed position during this movement.

CHAPTER III

METHODS

Subjects

This study was approved by the University of North Dakota Institutional Review Board, and Research Development and Compliance (IRB-201504-329) prior to the initiation of the study. Twelve healthy subjects (7 females and 5 males) volunteered to participate. Subjects were recruited through fliers posted throughout the School of Medicine and Health Sciences during the months of April through June 2015. Inclusion criteria included subjects between the ages of 20-40, right hand dominant, and ability to tolerate the prone and quadruped position for a maximum of 20 minutes each. Exclusion criteria included current or previous pathology of the shoulder or spine that required medical attention, pregnancy, and allergies to latex or isopropyl alcohol. The subjects' mean age, height, and weight were 23.3 years, 68.67 inches, and 155.67 pounds, respectively (Table 2). The subjects were fully informed of the experimental procedures, purpose, and possible risks of the present study. Each subject completed a demographic questionnaire (Appendix A) and a consent form (Appendix B) prior to the study.

Table 2. Subject Demographics

	Mean	Median	Standard Deviation
Age (Years)	23.3	23.5	1.4
Height (Inches)	68.7	68.5	2.8
Weight (Pounds)	155.7	152.5	19.1

Instrumentation

Instrumentation for this study included electromyography hardware and software. The electromyography (EMG) data collection was performed using self-adhesive pre-gelled surface EMG electrodes over the following muscles: LD, MT, and ES. BlueSensor Ag/Al adult electrodes with a 3.3 cm inter-electrode distance were utilized for this study (Ambu/Medicotest A/S, Denmark). Data analysis for the raw EMG data was performed using Noraxon MyoResearchXP software (Noraxon, USA, Scottsdale, AZ).

Electromyography

Prior to the initiation of the study, EMG equipment was set up and tested by the researchers to ensure proper signal transmission and reception. In order to ensure privacy and confidentiality of each participant, the research testing was completed in a private room in the Department of Physical Therapy on the University of North Dakota Campus in Grand Forks, ND. Each participant completed the study in one session lasting approximately one hour. Prior to beginning, study subjects received a verbal explanation of the study and were given an opportunity to ask any questions.

Subjects were asked to wear a tank top and shorts that would allow electrode placement directly on the skin on their back. Subject preparation and placement of electrodes were conducted following the guidelines of the SENIAM group.⁶ Collection of EMG data required electrode site preparation, electrode placement, connecting and testing the equipment. The electrode site preparation was performed in a standardized fashion including removing excess hair from the electrode site with an electric razor (when necessary), wiping the skin surface with 400 grit sandpaper, and wiping the area with isopropyl alcohol wipes.

Electrodes were placed over the LD, MT, and ES muscles parallel to the muscle fibers (Fig. 1). The same researcher measured and placed the electrodes on each participant to increase reliability. For the LD, the electrodes were placed over the muscle belly at T12 level and along a line connecting the most superior point of the posterior axillary fold and the S2 spinous process.^{12-14,20} For the MT, the electrodes were placed 4 cm lateral to the spinous process of T3.³² For the ES, the electrodes were horizontally aligned with the L3-4 interspace, 4 cm lateral to midline.^{1,7,11,16-19} The ground electrode was placed over the spinous process of T7. A Noraxon NorAngle electro goniometer (NoraxonUSA, Inc., Scottsdale, AZ) was placed with the distal segment over body of sacrum and proximal segment parallel to the lumbar spinous processes.

Skin impedance was assessed to be less than 10 k Ω by the Noraxon impedance analyzer (Noraxon, USA, Scottsdale, AZ). The impedance was measured by placing the analyzer over each pair of electrodes. The electrodes were connected to the Telemetry 900 transmitter that was placed in a belt around the subject's waist. The EMG signals were transmitted to the Telemetry 900 receiver and stored on a laptop computer (Hewlett Packard, Palo Alto, CA). The raw EMG data was later analyzed using the MyoResearch XP software (NoraxonUSA, Inc., Scottsdale, AZ).

Reflective markers were placed bilaterally over the acromion processes and bilateral anterior superior iliac spine (ASIS) for measurement of rotation. The testing positions were video recorded to analyze motion. A vertical point of reference was developed using a six-inch wooden box with a meter stick attached perpendicularly. The meter stick allowed the researchers to have the information needed in order to determine the amount of spinal rotation that occurs with each position. EMG data can be compared

to the different points of spinal rotation to determine at what point in rotation the analyzed musculature is most active. This data was not analyzed during the present study, but could be used in future studies. Once precise electrode placement was completed, maximal voluntary contraction data was collected.

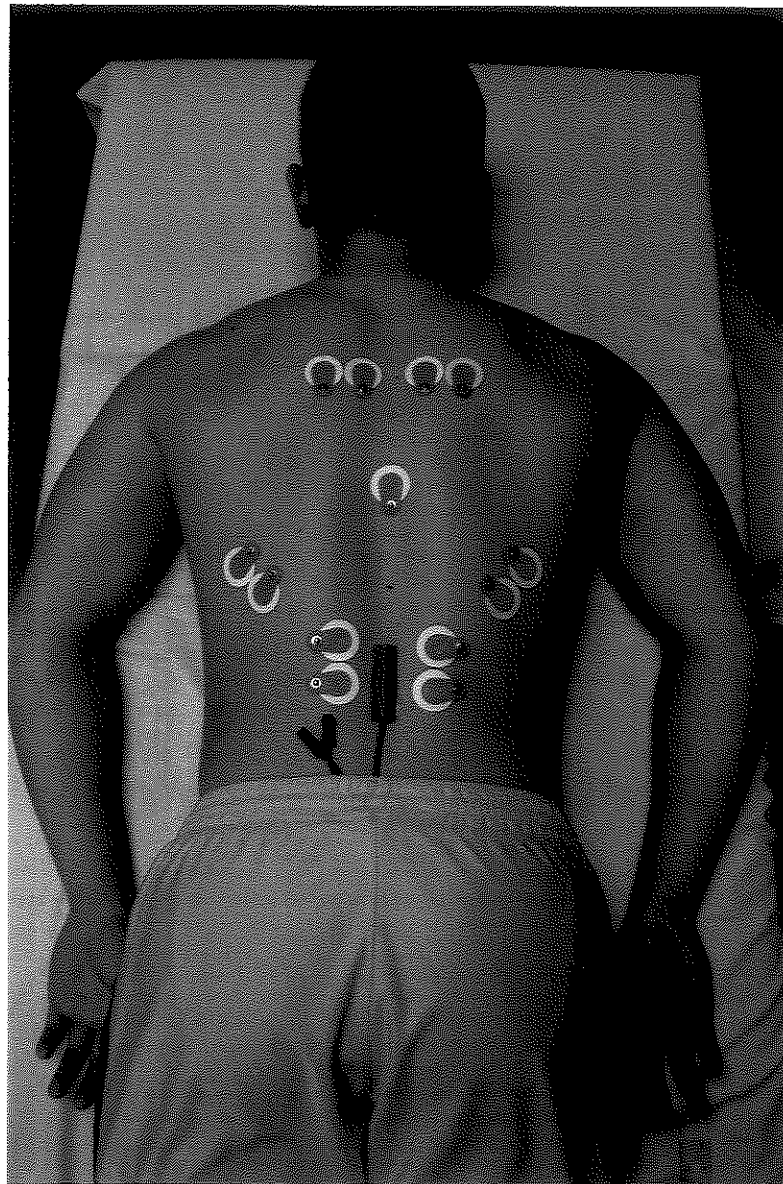


Figure 1. Goniometer, latissimus dorsi, middle trapezius, erector spinae and ground electrode placements

Maximal Voluntary Contraction

A maximal voluntary contraction for each muscle was obtained for normalization. The protocol used was established by the International Society of Electrophysiology and Kinesiology (ISEK). Participants started in the prone position with head resting in neutral for all MVC testing. For each MVC, participants were instructed to exert their maximal force against the dynamometer (microFET2) held by the researcher in one second, hold for three seconds, and return to resting position in one second. A metronome was used for consistent timing at a speed of 60 beats per minute. Participants were allowed to practice each MVC testing position until comfortable. Three trials were performed in each position with a 30 second rest between trials. Subjects were instructed to give their best effort on every trial. After each trial, participants were informed of their resistance value on the dynamometer in order to encourage the full MVC. No additional encouragement was given during the actual contraction. They were also reminded to contract slowly and fully, without jerking, in order to produce the best results.¹ Hand-held dynamometer values were recorded and used for reliability purposes for each test position. All trials were required to be within a five pound interval. If a trial resulted in a dynamometer value outside of the five pound interval, it was repeated until there were three recorded trials within five pounds of each other for each testing position. The MVC testing positions were randomized by computer for each participant. Once all of the MVC trials were completed, the participant was instructed on the spinal rotation movements in the standing and quadruped testing positions.

Latissimus dorsi (Fig. 2): The side being tested was aligned with the edge of the plinth, with the shoulder and upper extremity off the plinth. The participant was asked to fully flex their elbow and extend their humerus parallel to the trunk. The researcher applied resistance using a microFET2 handheld dynamometer at the distal humerus during upper extremity extension and adduction. Stabilization was applied to the ipsilateral scapula and contralateral pelvis.

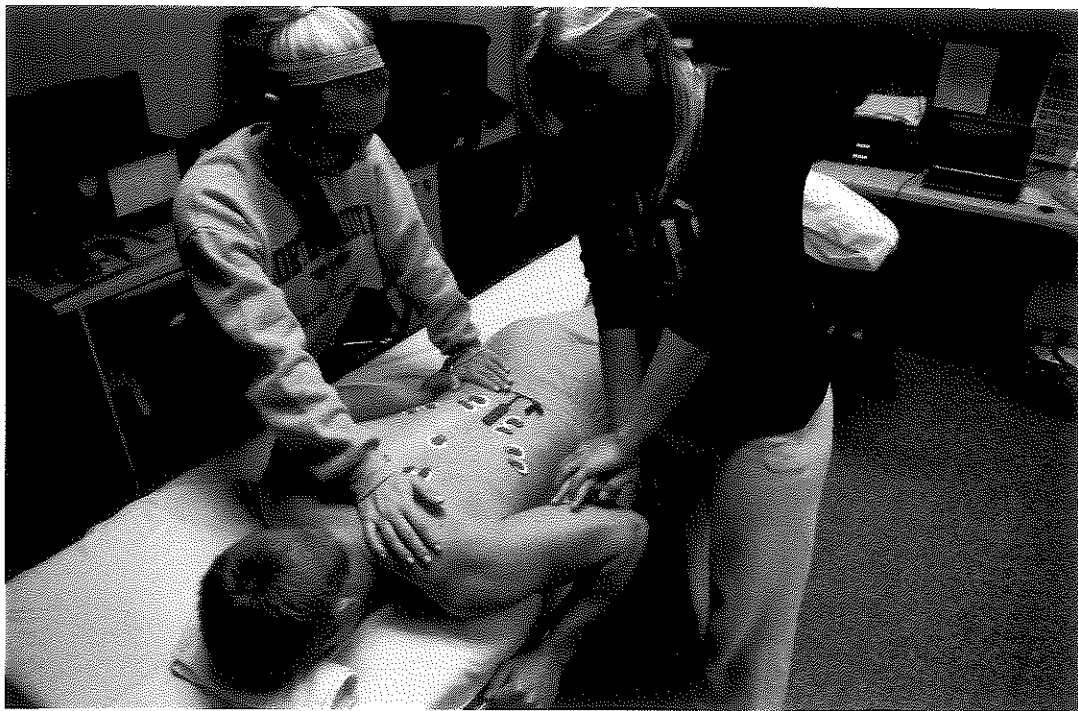


Figure 2. Testing position for the maximal voluntary contraction of the LD.

Middle trapezius (Fig. 3): the participant's upper extremity was placed in 90 degrees of shoulder abduction, neutral rotation and 90 degrees of elbow flexion. The researcher applied resistance using a microFET2 handheld dynamometer to the distal humerus during scapular retraction. Stabilization was provided to the contralateral scapula and ipsilateral pelvis.

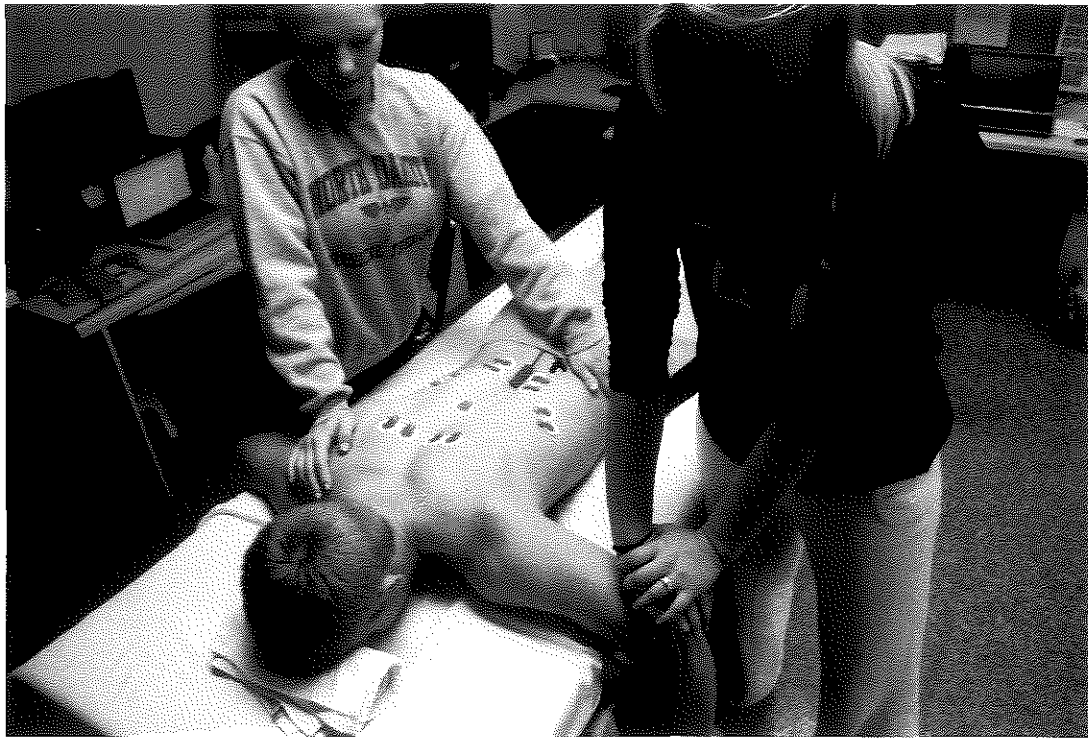


Figure 3. Testing positing for the maximal voluntary contraction of the MT.

Erector Spinae (Fig. 4): The participant placed their upper extremities at their sides. The pelvis and lower extremities were stabilized with Velcro belts attached to the plinth, as well as manual stabilization applied by a researcher at the ankles. The participant was instructed to lift their chest off the plinth into trunk extension through full range of motion while maintaining a neutral head position. No external resistance was applied. Consistent effort was measured by assessing full active range of motion prior to testing and ensuring full range was achieved during each trial.

Experimental Testing

The testing portion of the study was performed after the MVC testing. One to two minutes of rest was allowed prior to beginning the first testing position. The testing position sequence was randomized by computer for each participant to ensure any differences were not systematic. One to two minutes of rest was also given between

testing positions. Prior to data collection, each participant was allowed to practice the motion until comfortable. A 30 second rest break was given before recording the first trial. Each movement was paced by a metronome set at 92 beats per minute. Following the beat of the metronome, participants were instructed to move three counts into their full range of rotation followed by three counts back to the neutral position. A researcher verbally cued the patient during the motion to the beat of the metronome, saying, “Back, two, three, forward, two, three...” The participant completed three trials of five repetitions for each movement. There was a rest period of 30 seconds between each trial. A six-inch wooden block with a meter stick attached perpendicular to the testing surface was placed on the testing side to measure spinal rotation. The degree of spinal rotation could then be correlated to the level of EMG activity that occurred.

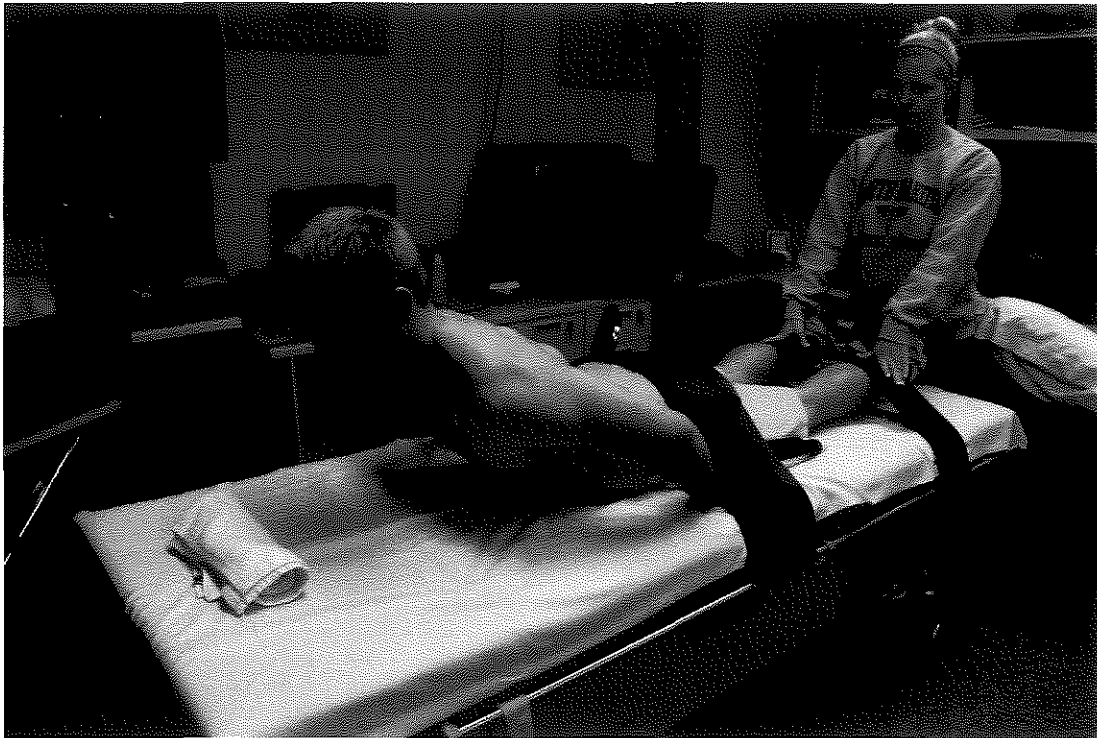


Figure 4. Testing position for the maximal voluntary contraction of the ES.

Standing (Fig. 5): Participants were asked to stand with feet flat on the floor, shoulder-width apart, and arms crossed across their chest. A researcher stabilized participant's shoulders by the coracoid and scapula to avoid movement of the upper trunk. The participants were instructed to rotate their pelvis by bringing their right ASIS posteriorly and left ASIS anteriorly (left spinal rotation), keeping their feet in contact with the floor and knees straight. This was repeated in the opposite direction bringing the left ASIS posteriorly and right ASIS anteriorly (right spinal rotation). The video camera was placed on the side rotating posteriorly with view of the reflective markers. The camera lens was placed at the height of the subject's ASIS for consistency.

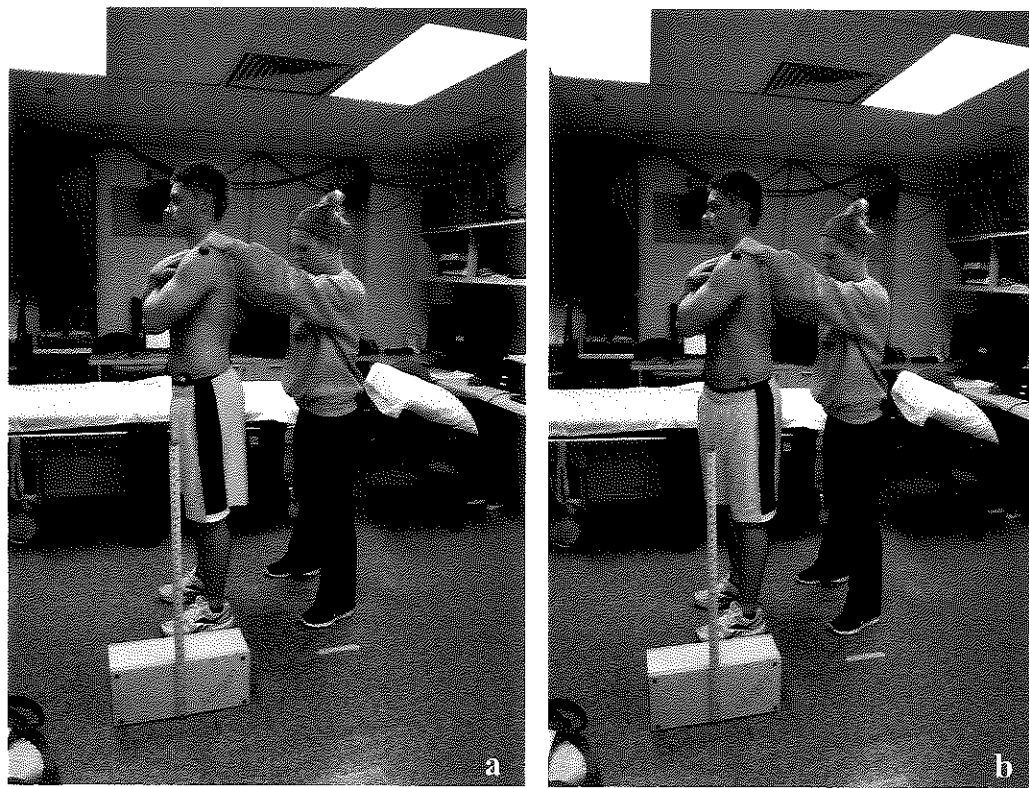


Figure 5. Standing spinal rotation (unfixed) testing position. (a) Starting position of the standing testing position. (b) Ending position of the standing testing position.

Quadruped (Fig. 6): For this testing position, participants were in a quadruped position with knees and hands shoulder-width apart. The 6" wooden box was placed adjacent to the participant's knee on the testing side. A towel was placed between the box and the participant's leg for greater ease of movement. The participants were asked to lift their knee off the plinth while maintaining contact with the box to prevent abduction of the thigh and to promote spinal rotation.

Data was collected during an entire cycle for each MVC and testing position and stored in separate files. Following the completion of the data collection, electrodes and motion analysis reflectors were removed from the subjects and the areas were cleaned with isopropyl alcohol.

Data Analysis

The collected EMG data was transported, rectified and normalized to the MVC by the Noraxon MyoResearchXP software. EMG data were recorded in 5-count intervals during every muscle contraction (MVCs and testing positions). To find the most precise data representation within the 5-count window, data from seconds 2 through 4 were used for data analysis. Once these values were obtained, all data were transferred to the Statistical Package for Social Sciences (SPSS) spreadsheet. A repeated measures ANOVA was used to determine a significant effect of each muscle in a fixed and non-fixed position on the EMG activity ($\alpha < 0.05$). A least significant difference (LSD) post hoc test was utilized to find significant differences between muscles.

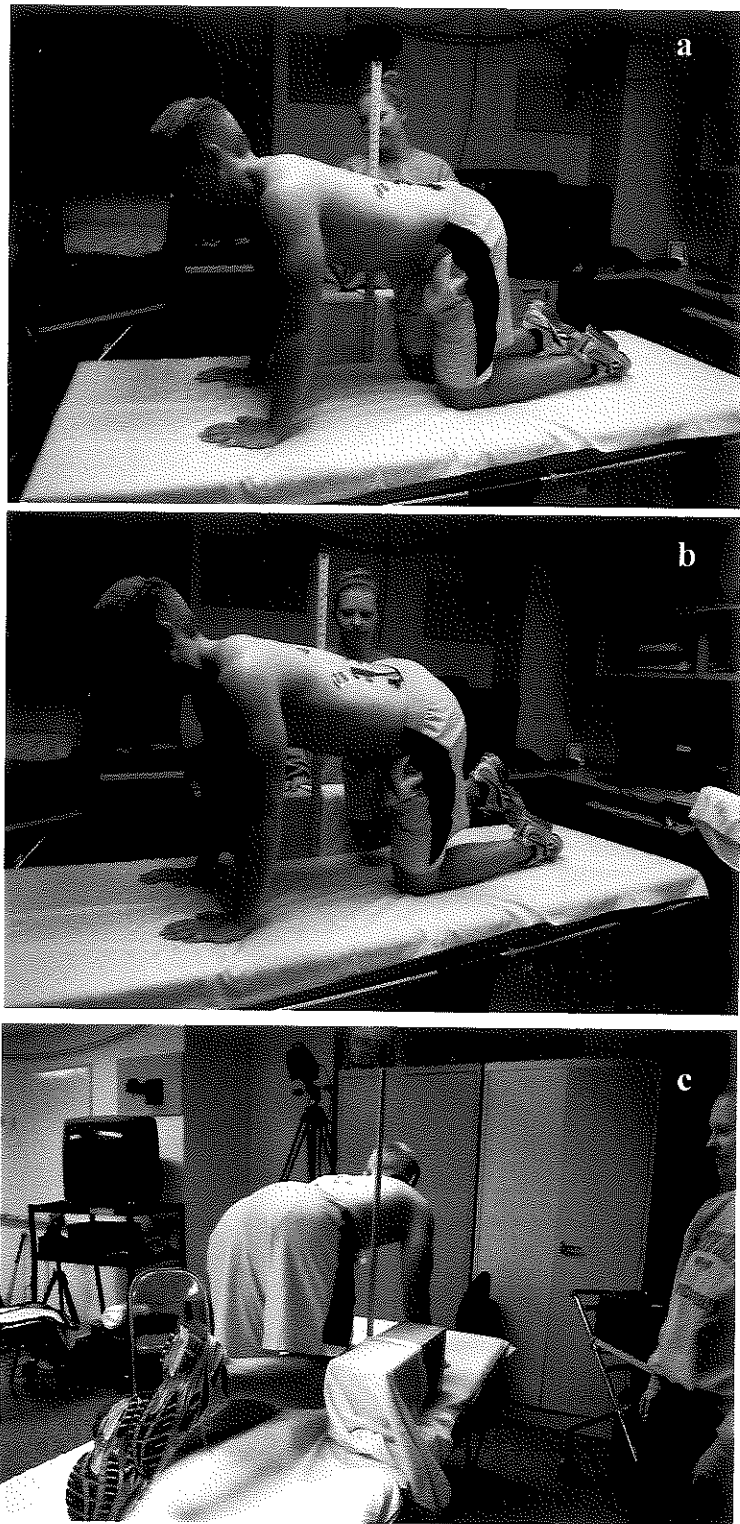


Figure 6. Quadruped spinal rotation (fixed) testing position. (a) starting position for quadruped test. (b) lateral view of ending position. (c) posterior lateral view of ending position.

CHAPTER IV

RESULTS

Each of the three research questions was analyzed using a repeated measures t-test or an ANOVA to analyze significant differences in EMG activity for specific muscles under the four conditions (Table 3). For an ANOVA to be found significant, the planned pairwise comparisons were compared using a least significant difference (LSD) post hoc test.

For the first research question comparing EMG function of the right and left latissimus dorsi under differing conditions of movement and upper extremity fixation, 4 repeated measure t-tests (RM t-test) were utilized, and a Bonferroni correction was made to decrease the experiment-wise error. Alpha was set at .0125. Of the 4 RM t-tests, two were found to be significant. See Table 3. The right latissimus dorsi was found to be most active during a left spine rotational movement when the upper extremities were fixed. Similarly, the left latissimus dorsi was found to be most active during right rotational movement when the upper extremities were fixed. (See Table 3 for the mean EMG MVC percentages.)

The second research question compared the EMG activity of the latissimus dorsi, middle trapezius and erector spinae muscles during left and right spinal rotation with the upper extremities fixed (quadruped). A Repeated Measures Analysis of Variance was used, and specific pair-wise comparisons addressed differences between the latissimus

dorsi and the ipsilateral middle trapezius, and the latissimus dorsi and the ipsilateral erector spinae.

Table 3: Repeated Measures t-test: The difference in EMG activity between fixed and non-fixed positions for movement R and movement L for the right latissimus dorsi and also for the left latissimus dorsi.

Muscle	Movement Direction*	Position	N	Mean (% MVC)	SD	t	df	p
R Latissimus Dorsi	Right	Fixed	12	10.41	7.63	-1.36	11	.201
		Non-fixed	12	6.65	5.79			
	Left	Fixed	12	26.89	11.36	-5.04	11	<.001
		Non-fixed	12	10.30	9.13			
L Latissimus Dorsi	Right	Fixed	12	36.24	15.14	-5.04	-5.13	<.001
		Non-fixed	12	12.96	11.16			
	Left	Fixed	12	8.80	5.54	-1.94	11	.078
		Non-fixed	12	6.01	3.56			

*right movement direction= left spinal rotation; left movement direction= right spinal rotation

The Repeated Measures Analysis demonstrated a significant difference in EMG activity (MVC percentage) between the muscles under conditions of left and right spinal rotation with the upper extremities fixed. See Table 4 for comparisons of the muscles in the fixed position. The right ES was more active than both the LD and MT during the condition of fixed upper extremities and movement right. Likewise, the left ES was more active than both muscles during the condition of fixed upper extremities and movement left. When the upper extremities were fixed during the right movement, the left LD was more active than the other 2 muscles. (See Table 4 for the mean EMG MVC percentages.)

CHAPTER V

DISCUSSION and CONCLUSION

Discussion

The purpose of this study was to determine the EMG activity of the LD, MT, and ES during spinal rotation with and without fixation of the upper extremities. The results of this study indicate a statistically significant increase in LD EMG activity when in the fixed (quadruped) position when compared to the non-fixed (standing) position, supporting hypothesis 1. While past research has shown that the LD does not play a significant role in spinal rotation, this pilot study suggests that when in the quadruped position, the LD contributes to ipsilateral spinal rotation.

In the right fixed position, the left LD had significantly higher EMG activity than the MT and ES. This was not found to be true in the left fixed position. This could be attributed to the small sample size of the study, hand dominance, or limited practice time. The quadruped position decreases the degree of lumbar lordosis of the spine due to hip flexion, which may give the LD more advantage in spinal rotation and inhibit the MT and ES. In contrast, the ES may have a better biomechanical advantage than the LD in the standing position due to the natural lordotic curve of the spine, causing an anterior pelvic tilt of the pelvis and greater line of pull.

In the standing position, the LD did not exhibit significantly more EMG activity than the MT and ES. In fact, the ES had significantly more EMG activity than the LD and MT. This was statistically significant in 3 out of 4 testing conditions. As previously

mentioned, this testing position allowed more freedom to move into lumbar extension, it is possible the ES may have compensated the movement by overpowering the LD.

This study resulted in agreement with previous studies conducted by Kumar et al.¹ that the LD muscle has a significant influence on spinal rotation. Kumar et al.¹ focused attention on the involvement of the LD during isometric rotation and lifting activities. The present study was conducted differently from previous research, as the testing positions conducted are more closely related to exercises that would be conducted in a physical therapy setting.

There were a few limitations to this study. First, there was a small sample size of 12 individuals. Second, the research study included a narrow population that consisted of healthy, 20-30 year old physical therapy students rather than the general population. Third, there may have been other confounding variables the researchers were not aware of during the experimentation process. Lastly, the use of surface electrodes, instead of intramuscular, was a limitation because crosstalk from other muscles may have occurred.

Areas of future research could include gender differences in muscle activation during spinal rotation, a more specific degree of rotation at which the LD is most active, and comparison of left/right LD with hand dominance. Also, increasing the sample size would increase the statistical significance of the results. It would be beneficial to test subjects with spinal pathology to test for statistical differences in muscle activation. Eventually, it may be beneficial to investigate the outcomes of physical therapy with the integration of LD focused exercises.

Conclusion

The LD was found to be more active during the fixed positional movements. When standing without the upper extremities fixed, other muscles have a greater function in rotation of the spine. The ES muscles, for example, have a greater effect in this position compared to the LD. Although the LD is active without the arms fixed, it demonstrates a significantly greater muscle activity when placed in a quadruped position.

This pilot study highlights the contributions of the LD muscle with spinal rotation and is the beginning of ongoing research efforts to address LD as part of the rotational movement strategy in individuals both with and without LBP. Many everyday movements require spinal rotation with the UEs fixed. Frequently, rehabilitation for LBP includes positions such as standing and quadruped. LD is a muscle that should be considered when looking at spinal rotational movement systems.

APPENDIX A

ID # _____

Patient Questionnaire

Name _____

Date of Birth _____ Height _____ Weight _____

Dominant Arm _____

Sensitivity to: Latex Y N Isopropyl Alcohol skin sensitivity Y N

If yes, please explain _____

Do you have any history of shoulder pain/pathology? Y N

If yes, please explain _____

Do you have any history of back or spinal disc/pathology? Y N

If yes, please explain _____

Are you pregnant? Y N

Do you have any condition for which lying on your stomach would be a problem? Y N

If yes, please explain _____

All the information provided in this questionnaire has been answered accurately and to the best of my knowledge.

Signature of participant _____

Date _____

APPENDIX B

**THE UNIVERSITY OF NORTH DAKOTA
CONSENT TO PARTICIPATE IN RESEARCH**

TITLE: *Electromyographic Analysis of Latissimus Dorsi, Erector Spinae and Middle Trapezius Muscle Activity During Trunk Rotation*

PROJECT DIRECTOR: *Susan H N Jeno, PT, PhD*

PHONE # *701 777-3662*

DEPARTMENT: *Physical Therapy*

STATEMENT OF RESEARCH

A person who is to participate in the research must give his or her informed consent to such participation. This consent must be based on an understanding of the nature and risks of the research. This document provides information that is important for this understanding. Research projects include only subjects who choose to take part. Please take your time in making your decision as to whether to participate. If you have questions at any time, please ask.

WHAT IS THE PURPOSE OF THIS STUDY?

You are invited to be in a research study about muscle activity during trunk rotation because you are a student in the UND School of Medicine and Health Sciences.

The purpose of this study is to determine the level of muscle activity of several back muscles including latissimus dorsi, middle trapezius, and erector spinae muscles with trunk rotation with and without fixation of the upper extremities. The conclusions drawn from this study will allow practicing clinicians to better develop the exercise programs provided to their clients with back or upper extremity pathology.

HOW MANY PEOPLE WILL PARTICIPATE?

Approximately 50 people will take part in this study at the University of North Dakota

HOW LONG WILL I BE IN THIS STUDY?

Your participation in the study will last approximately 60 minutes. You will need to visit the Department of Physical Therapy 1 time to participate in this study.

WHAT WILL HAPPEN DURING THIS STUDY?

After you agree to participate in this study, you will be asked to complete a questionnaire pertaining to information about you. You are free to skip any question that you would prefer not to answer. This study will involve the collection of electrical activity of some of the muscles in your back while you perform trunk rotation activities while standing upright and while on your hands and knees. In order to access the muscles on your back and for comfort during the test

Date _____
Subject Initials: _____

procedures, female subjects will be asked to wear shorts and a swimsuit top or sports bra to expose the appropriate areas of your back for placement of the electrodes. For male subjects, you will be asked to wear shorts and remove your shirt to expose your back. You will be asked to lie on your stomach on a padded table and marks will be placed on your skin where the electrodes will be placed over the muscles on both sides of your back (see attached diagram). Pre-gelled, self-adhesive electrodes placed over the muscles will collect the electrical signal the muscles produce when they contract. In order to obtain the best signal from the muscles, the skin where the electrodes will be placed will be prepared in standard fashion which includes clipping any excess hair with an electric razor, lightly rubbing the skin with fine grit sandpaper followed by cleaning the area with rubbing alcohol wipes. This process is intended to reduce the resistance of the skin to allow of better signal collection by the electrodes. A device to measure the amount of rotation will be placed along the spine in the low back area. The data collecting devices will be attached by lead wires to a transmitter which will be attached around your waist by a belt. Electrical signals are sent from the transmitter to a computer for recording and analysis.

Once the electrodes are in place, you will be asked lie on your stomach and to perform a maximal voluntary contraction (MVC) – a full effort contraction - of each of the muscles which will be used for comparison of muscle activity. A hand-held device will be used to record the amount of force created by each contraction. For each MVC, you will be asked to push against a fixed device as hard as you can for 5 seconds. This will be repeated 3 times for each muscle with 30-60 seconds rest between trials. You will be allowed to practice the testing procedure before data collection.

Following the collection of the MVC data, you will be asked to perform a series of trunk rotations both to the right and to the left from a standing position and from a position on your hands and knees. Each rotation will be timed with a metronome for a 3 count motion to obtain full rotation and a 3 count motion to return to a resting position. You will be allowed to practice to be sure the timing of the motions is clear. The rotation measurements will be randomized with you selecting a card to determine the order of the activities. You will perform 5 repetitions of each rotation timed by a metronome for each trial. You will be given 30-60 seconds rest between each trial. The rotational motions will be recorded on the computer for use in analyzing the data.

WHAT ARE THE RISKS OF THE STUDY?

Although there is some degree of risk involved in physical activity testing, the researchers believe the risk of injury and discomfort is minimal; however, minor muscle soreness may occur following repeated activity. The use of a spotter will minimize any risk from loss of balance during the activity. Reddening of the skin in the areas where the electrodes are placed is possible due to the adhesive material. The EMG equipment will only monitor muscle activity and the equipment will not cause discomfort. If at any time you experience pain, discomfort, fatigue, or any other uncomfortable symptoms, you may stop your participation in this study.

WHAT ARE THE BENEFITS OF THIS STUDY?

You may not benefit personally from being in this study. However, we hope that, in the future, other people might benefit from this study and these benefits include but are not limited to 1) gaining a better understanding of the muscle activity in the back muscles with trunk rotation and 2) increasing the current level of knowledge of muscle activity and motion patterns of these muscles during this activity. This will begin to provide more information on how to design treatment programs that include these muscles.

WILL IT COST ME ANYTHING TO BE IN THIS STUDY?

You will not have any costs for being in this research study.

WILL I BE PAID FOR PARTICIPATING?

You will not be paid for being in this research study.

WHO IS FUNDING THE STUDY?

The University of North Dakota and the research team are receiving no payments from other agencies, organizations, or companies to conduct this research study.

CONFIDENTIALITY

The records of this study will be kept private to the extent permitted by law. In any report about this study that might be published, you will not be identified. Your study record may be reviewed by Government agencies, the UND Research Development and Compliance office, and the University of North Dakota Institutional Review Board.

Any information that is obtained in this study and that can be identified with you will remain confidential and will be disclosed only with your permission or as required by law. Confidentiality will be maintained as each subject will be given a randomly selected identification number at the beginning of the study, which will be known by the researchers only. All information involving the research study, digital and hard copy, along with a hard copy of the statistically analyzed data, will be secured in a locked cabinet inside the Department of Physical Therapy at the University of North Dakota. Unless the data is required for future studies, the information will be destroyed via shredding three years after the study has been completed.

If we write a report or article about this study, we will describe the study results in a summarized manner so that you cannot be identified.

EMG data and digital recordings of the motions performed as part of this research study will be coded in the same manner as the information form. Your name will not be associated with the digital file. All digital information will be stored separately from the consent forms in a secure location in the Department of Physical Therapy. After a period of 3 years from the completion

of the study, the digital data will be deleted from all disks/drives. You are free to look at the digital recordings of your muscle activity at the conclusion of the data collection period.

COMPENSATION FOR INJURY

In the event that this research activity results in an injury, treatment will be available including first aid, emergency treatment and follow-up care as needed. Payment for any such treatment is to be provided by you (you will be billed) or your third-party payer, if any (such as health insurance, Medicare, etc.) No funds have been set aside to compensate you in the event of injury. Also, the study staff cannot be responsible if you knowingly and willingly disregard the directions they give you.

IS THIS STUDY VOLUNTARY?

Your participation is voluntary. You may choose not to participate or you may discontinue your participation at any time without penalty or loss of benefits to which you are otherwise entitled. Your decision whether or not to participate will not affect your current or future relations with the University of North Dakota.

The investigators or you may stop the experiment at any time if you are experiencing discomfort, pain, fatigue, or any other symptoms that may be detrimental to your health. If you agree to participate, you will be allowed to stop your participation in this study at any time without prejudice or jeopardizing any future relationships with the UND Department of Physical Therapy.

CONTACTS AND QUESTIONS?

The researcher conducting this study is Susan H. N. Jenó, PT, PhD. You may ask any questions you have now. If you later have questions, concerns, or complaints about the research please contact Susan Jenó at 701 777-2831 during the day.

If you have questions regarding your rights as a research subject, you may contact The University of North Dakota Institutional Review Board at (701) 777-4279.

- You may also call this number about any problems, complaints, or concerns you have about this research study.
- You may also call this number if you cannot reach research staff, or you wish to talk with someone who is independent of the research team.
- General information about being a research subject can be found by clicking "Information for Research Participants" on the web site:
<http://und.edu/research/resources/human-subjects/research-participants.cfm>

I give consent to be videotaped during this study.

Please initial: ☐ Yes ☐ No

4

Date: _____
Subject Initials: _____

Your signature indicates that this research study has been explained to you, that your questions have been answered, and that you agree to take part in this study. You will receive a copy of this form.

Subjects Name: _____

Signature of Subject

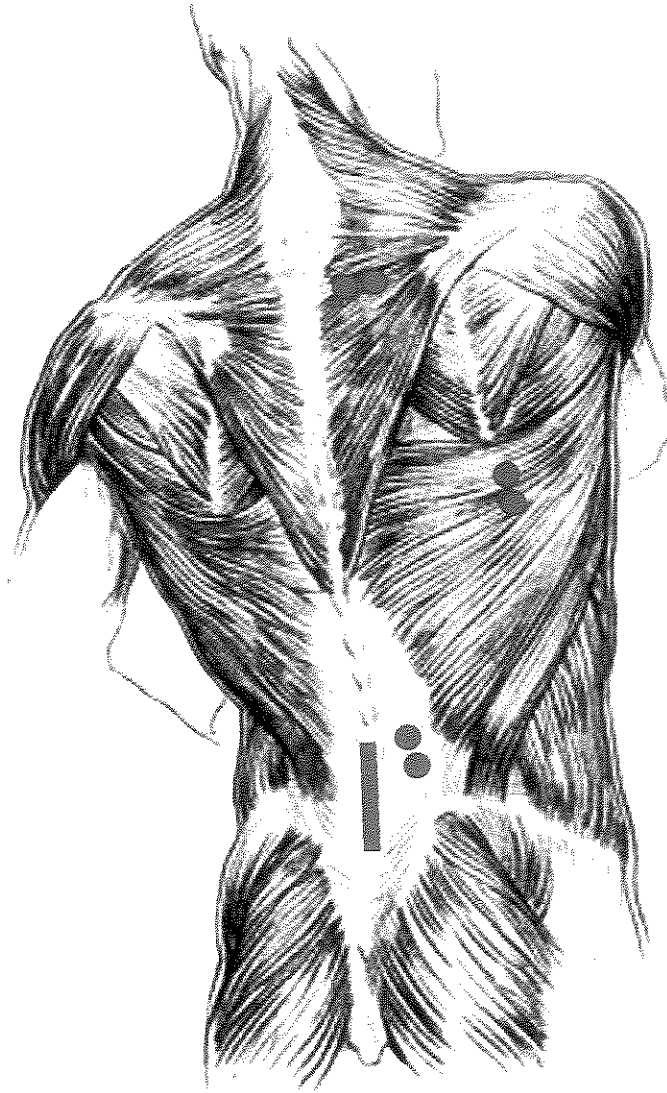
Date

I have discussed the above points with the subject or, where appropriate, with the subject's legally authorized representative.

Signature of Person Who Obtained Consent

Date

Location of electrodes on your back. Electrodes are placed on both sides of the back (small circles). The large bar indicates the position of the joint angle measurement tool.



APPENDIX C

University of North Dakota Human Subjects Review Form
January 2015 Version

All research with human participants conducted by faculty, staff, and students associated with the University of North Dakota, must be reviewed and approved as prescribed by the University's policies and procedures governing the use of human subjects. It is the intent of the University of North Dakota (UND), through the Institutional Review Board (IRB) and Research Development and Compliance (RD&C), to assist investigators engaged in human subject research to conduct their research along ethical guidelines reflecting professional as well as community standards. The University has an obligation to ensure that all research involving human subjects meets regulations established by the United States Code of Federal Regulations (CFR). When completing the Human Subjects Review Form, use the "IRB Checklist" for additional guidance.

Please provide the information requested below. Handwritten forms are not accepted -- responses must be typed on the form.

Principal Investigator: Susan H N. Jeno, PT, PhD

Telephone: 777-3662

E-mail Address: sue.jeno@med.und.edu

Complete Mailing Address: 501 North Columbia Road Stop 9037 Grand Forks, ND 58202-9037

School/College: SMHS

Department: PT

Student Advisor (if applicable): _____

Telephone: _____

E-mail Address: _____

Address or Box #: _____

School/College: _____

Department: _____

***** All IRB applications must include a Key Personnel Listing.**

Project Title: EMG Analysis of Latissimus Dorsi, Erector Spinae and Middle Trapezius Muscle Activity During Trunk

Rotation

Proposed Project Dates: Beginning Date: April 15, 2015

Completion Date: April 15, 2016

(Including data analysis)

Funding agencies supporting this research: N/A

Did the contract with the funding entity go through UND Grants and Contracts Administration? ☐ YES or ☒ NO

Attach a copy of the contract. Do not include any budgetary information. The IRB will not be able to review the study without a copy of the contract with the funding agency.

Does any researcher associated with this project have an economic interest in the research, or act as an officer or a director of any outside entity whose financial interests would reasonably appear to be affected by the research? If yes, submit on a separate piece of paper an additional explanation of the financial interest. The Principal Investigator and any researcher associated with this project should have a Financial Interests Disclosure Document on file with their department.

☐ YES or ☒ NO

Will any research participants be obtained from another organization outside the University of North Dakota (e.g., hospitals, schools, public agencies, American Indian tribes/reservations)?

☐ YES or ☒ NO

Will any data be collected at or obtained from another organization outside the University of North Dakota?

☐ YES or ☒ NO

If yes to either of the previous two questions, list all organizations:

Letters from each organization must accompany this proposal. Each letter must illustrate that the organization understands its involvement and agrees to participate in the study. Letters must include the name and title of the individual signing the letter and should be printed on organizational letterhead.

Does any external site where the research will be conducted have its own IRB? ☐ YES ☐ NO ☐ N/A

If yes, does the external site plan to rely on UND's IRB for approval of this study? ☐ YES ☐ NO ☐ N/A
(If yes, contact the UND IRB at 701 777-4279 for additional requirements)

If your project has been or will be submitted to other IRBs, list those Boards below, along with the status of each proposal.

_____	Date submitted: _____	Status: <input type="checkbox"/> Approved <input type="checkbox"/> Pending
_____	Date submitted: _____	Status: <input type="checkbox"/> Approved <input type="checkbox"/> Pending

(include the name and address of the IRB, contact person at the IRB, and a phone number for that person)

Type of Project: Check "Yes" or "No" for each of the following.

- | | | | |
|--|--|--|---------------------------------------|
| <input checked="" type="checkbox"/> YES or <input type="checkbox"/> NO | New Project | <input type="checkbox"/> YES or <input checked="" type="checkbox"/> NO | Dissertation/Thesis/Independent Study |
| <input type="checkbox"/> YES or <input checked="" type="checkbox"/> NO | Continuation/Renewal | <input type="checkbox"/> YES or <input checked="" type="checkbox"/> NO | Student Research Project |
| <input type="checkbox"/> YES or <input checked="" type="checkbox"/> NO | Is this a Protocol Change for previously approved project? If yes, submit a signed Protocol Change Form, along with a signed copy of this form with the changes bolded or highlighted. | | |
| <input type="checkbox"/> YES or <input checked="" type="checkbox"/> NO | Does your project involve abstracting medical record information? If yes, complete the HIPAA Compliance Application and submit it with this form. | | |
| <input type="checkbox"/> YES or <input checked="" type="checkbox"/> NO | Does your project include Genetic Research? | | |

Subject Classification: This study will involve subjects who are in the following special populations: Check all that apply.

- | | |
|--|--|
| <input type="checkbox"/> Children (< 18 years) | <input checked="" type="checkbox"/> UND Students |
| <input type="checkbox"/> Prisoners | <input type="checkbox"/> Pregnant Women/Fetuses |
| <input type="checkbox"/> Cognitively impaired persons or persons unable to consent | |
| <input type="checkbox"/> Other _____ | |

Please use appropriate checklist when children, prisoners, pregnant women, or people who are unable to consent will be involved in the research.

This study will involve: Check all that apply.

- | | |
|---|--|
| <input type="checkbox"/> Deception (Attach Waiver or Alteration of Informed Consent Requirements) | <input type="checkbox"/> Stem Cells |
| <input type="checkbox"/> Radiation | <input type="checkbox"/> Discarded Tissue |
| <input type="checkbox"/> New Drugs (IND) IND # _____ Attach Approval | <input type="checkbox"/> Fetal Tissue |
| <input type="checkbox"/> Investigational Device Exemption (IDE) # _____ Attach Approval | <input type="checkbox"/> Human Blood or Fluids |
| <input type="checkbox"/> Non-approved Use of Drug(s) | <input type="checkbox"/> Other _____ |
| <input checked="" type="checkbox"/> None of the above will be involved in this study | |

I. Project Overview

Please provide a brief explanation (limit to 200 words or less) of the rationale and purpose of the study, introduction of any sponsor(s) of the study, and justification for use of human subjects and/or special populations (e.g., vulnerable populations such as children, prisoners, pregnant women/fetuses).

To date, the research concerning the activation of the latissimus dorsi muscle focuses on its contribution to upper extremity movement. With attachments on spinous processes, the latissimus dorsi as well as the middle trapezius has the potential to impact spinal rotation. Without proper identification of these muscles' contribution to spinal rotation, proper rehabilitation of a patient with upper extremity or spinal pathology would be impossible. This pilot project is intended to analyze the activation of the latissimus dorsi, middle trapezius and for comparison, the erector spinae muscles during spinal rotation to identify the muscles' contribution to this biomechanical movement.

II. Protocol Description

Please provide a thorough description of the procedures to be used by addressing the instructions under each of the following categories.

1. Subject Selection.

- a) Describe recruitment procedures (i.e., how subjects will be recruited, who will recruit them, where and when they will be recruited and for how long) and include copies of any advertisements, fliers, etc., that will be used to recruit subjects.
Investigators will voluntarily recruit subjects through fliers posted throughout the SMHS during the months of April-June 2015. No incentives will be provided to participants in this study. See attached flier. (See attached)
- b) Describe your subject selection procedures and criteria, paying special attention to the rationale for including subjects from any of the categories listed in the "Subject Classification" section above.
Subjects will be between the ages of 20-40, have no history of shoulder or spine pathology. They will also be able to lay in a prone position for a maximum of 20 minutes and maintain a 4-point quadruped position for approximately 15 minutes during the testing procedure. Subjects from the SMHS will be recruited as a sample of convenience.
- c) Describe your exclusionary criteria and provide a rationale for excluding subject categories.
Exclusion criteria include pathology to the shoulder or spine that required medical attention, if the subject is pregnant, or has allergies to latex or isopropyl alcohol. Any of these criteria would pose a risk for the subject to participate in the research study.
Exclusion criteria for this study include: 1) history of shoulder or spine pathology - differences in electrical activity and functional movements associated with pathology could alter the patterns demonstrated during the testing procedure and subjects will be asked to perform an isometric contraction of the shoulder extensors, scapular retractors and trunk extensors which may exacerbate previous pathologies; 2) age of subjects less than 20 years or greater than 40 years. Differences in muscle physiology in younger and older individuals could enhance variability between subjects; 3) sensitivity to isopropyl alcohol or latex - electrodes used during the procedure may contain trace amounts of latex; skin is cleaned with isopropyl alcohol; in an effort to avoid adverse reactions, individuals with these sensitivities will be excluded from participation in this study.
- d) Describe the estimated number of subjects that will participate and the rationale for using that number of subjects.
It is anticipated that a maximum of 50 healthy UND students will be recruited for this study to reduce the risk of research error associated with smaller sample sizes.
- e) Specify the potential for valid results. If you have used a power analysis to determine the number of subjects, describe your method.
Valid results are anticipated with a sample size of up to 50 subjects and randomization of the order of the testing position during the data collection protocol to minimize the error associated with training effects or fatigue.

2. Description of Methodology.

- a) Describe the procedures used to obtain informed consent.
Informed consent will be obtained from each subject through the information and consent form (see attached form). All individuals participating in this study will be capable of independent decision making and will sign a consent form stating their understanding and willingness to participate in this study. A copy of the consent form will be provided for each subject.
- b) Describe where the research will be conducted. Document the resources and facilities to be used to carry out the proposed research. Please note staffing, funding, and space available to conduct this research.
All data collection will occur within a private room in the UND Department of Physical Therapy within the SMHS. EMG equipment owned by the Department will be utilized for all data collection.
- c) Indicate who will carry out the research procedures.
Research will be carried out by Dr. Sue Jenö and Year 2 Graduate Physical Therapy Students.
- d) Briefly describe the procedures and techniques to be used and the amount of time that is required by the subjects to complete them.

Electromyographic (EMG) activity of the muscles will be monitored during standing trunk rotation and trunk rotation in a 4-point quadruped position with the use of pre-gelled, self-adhesive electrodes placed over motor points of the relevant muscles in the back. Muscles to be monitored include the latissimus dorsi, middle trapezius, erector spinae muscles on both sides of the body. Precise electrode placement will be determined by standard electrode placement charts and previously published research. Female subjects will be asked to wear shorts and bathing suit top and male subjects will be asked to wear shorts to facilitate access to the muscles and protect modesty. Prior to electrode placement, the skin will be prepared in standardized fashion and skin impedance will be measured to ensure adequate electrical conduction at each site. Preparation of the skin includes removing excess hair in the area where the electrodes will be positioned with an electric razor, the skin slightly abraded with sandpaper and then cleaned with alcohol wipes. A goniometer attachment will be placed along the lumbar spinous processes to record trunk rotation. The electrodes and goniometer will be connected to a transmitter which will be placed in a belt around the subject's waist. The EMG signals will be transmitted to a receiver and then to a computer. Raw EMG data will be obtained for analysis.

Once the electrodes are in place, each subject will perform a maximal voluntary contraction (MVC) of each of the muscles on both sides of the body for muscle activity comparison. A hand-held device will be utilized to record the amount of force generated by each contraction in addition to the EMG data. Each exercise will be performed 3 times, held for 5 seconds with 30-60 sec rest between trials. The MVC testing position for all muscles is a prone position; latissimus dorsi (LD) - resistance to arm extension from a neutral position will be used to record the MVC; middle trapezius (MT) - the arm will be abducted to 90 degrees with the elbow bent to 90 degrees and scapular retraction will be resisted at the proximal humerus; erector spinae (ES) muscles - trunk extension with the arms at sides with resistance provided across the upper back. Subjects will be allowed to practice the testing and rotation activities prior to data collection to ensure understanding of the motions and appropriate speed of motion. Following the data collection of the MVC, a series of trunk rotations both to the right and to the left from a standing position and from a 4-point quadruped position will be performed with the order randomized to avoid research bias or error. Each rotation will be timed with a metronome for a 3 count motion to obtain full rotation and a 3 count motion to return to a neutral position. Subjects will be asked to perform 5 continuous repetitions of each rotation paced by a metronome for each trial. A rest of 30-60 seconds will be provided between each trial. The rotational motions will be digitally video recorded for use in analyzing the EMG data.

- e) Describe audio/visual procedures and proper disposal of tapes.
Video recording is directly linked to the computer and EMG data for analysis. No actual audio recordings are made of the subjects. Video recordings will be utilized in the data analysis process, saved and stored in similar fashion as the EMG data and destroyed simultaneously. No separate tapes are created in this process.
- f) Describe the qualifications of the individuals conducting all procedures used in the study.
The primary investigator for this study is a faculty member in the Department of Physical Therapy who will be assisted by Year 2 Graduate Physical Therapy students all of whom are trained in the use of EMG equipment.
- g) Describe compensation procedures (payment or class credit for the subjects, etc.).
There will be no compensation given to subjects involved in this study.

Attachments Necessary: Copies of all instruments (such as survey/interview questions, data collection forms completed by subjects, etc.) must be attached to this proposal.

3. Risk Identification.

- a) Clearly describe the anticipated risks to the subject/others including any physical, emotional, and financial risks that might result from this study.
The potential physical risks associated with this study are minimal. The EMG electrode placement and analysis is a non-invasive procedure utilized in clinical practice. During the performance of the

MVC contractions and trunk rotation activities, there is a slight chance the subject may lose balance or experience shoulder or back pain. This potential risk will be minimized by the presence of a spotter during the activity. Minor skin irritation from the skin preparation and EMG electrodes is possible. Subjects may experience slight fatigue or muscle soreness following participation in this study but it is anticipated that this would not be any worse than that experienced during minimal physical exercise. All subjects will be healthy with no history of shoulder or spine pathology so these risks are minimized by inclusion/exclusion criteria.

- b) Indicate whether there will be a way to link subject responses and/or data sheets to consent forms, and if so, what the justification is for having that link.
 Subject's names will not be used in any reports of the results of this study. Each participant will be assigned an identification number, known only by the investigators, which will be the only association between consent forms and data collected by EMG. Any information that is obtained in connection with this study and that can be identified with the subject will remain confidential and will be disclosed only with permission from the subject. At the completion of the study, the research data and the consent forms will be stored in separate locked locations in the Department of Physical Therapy for 3 years at which point the forms will be shredded and electronic data deleted. Data will be reported in aggregate form only to protect the confidentiality of all subjects.
- c) Provide a description of the data monitoring plan for all research that involves greater than minimal risk.
- d) If the PI will be the lead-investigator for a multi-center study, or if the PI's organization will be the lead site in a multi-center study, include information about the management of information obtained in multi-site research that might be relevant to the protection of research participants, such as unanticipated problems involving risks to participants or others, interim results, or protocol modifications.

4. Subject Protection.

- a) Describe precautions you will take to minimize potential risks to the subjects (e.g., sterile conditions, informing subjects that some individuals may have strong emotional reactions to the procedures, debriefing, etc.).
 Selection of the subject pool utilizing the exclusion criteria will minimize the risks associated with this study. Limiting the trunk rotation to what the subject can complete comfortably will also limit potential risks of back pain associated with trunk rotation. Muscle soreness will be minimized by limiting the number of repetitions in each position. The possibility of skin irritation will be minimized by proper skin preparation and subject screening prior to participation. To protect confidentiality and modesty, all data collection will occur in a private room. The investigators or participant may stop the experiment at any time if the participant is experiencing discomfort, pain, fatigue, or any other symptoms that may be detrimental to his/her health. All subjects will be allowed to terminate their participation in this study at any time without prejudice.
- b) Describe procedures you will implement to protect confidentiality and privacy of participants (such as coding subject data, removing identifying information, reporting data in aggregate form, not violating a participant's space, not intruding where one is not welcome or trusted, not observing or recording what people expect not to be public, etc.). If participants who are likely to be vulnerable to coercion and undue influence are to be included in the research, define provisions to protect the privacy and interests of these participants and additional safeguards implemented to protect the rights and welfare of these participants.
 Subject and result information will not be linked to the consent form in order to protect the confidentiality of the subjects. Names will not be associated with data collection forms. Subjects will be assigned a confidential, unique number which will be used for identification purposes. To protect confidentiality and modesty, all data collection will occur in a private room.
- c) Indicate that the subject will be provided with a copy of the consent form and how this will be done.

Prior to participation in this study, each subject will read and sign a consent form. Participants in this study will all be capable of independent decision making and will sign a consent form stating their understanding and willingness to participate in this study. Participants will be encouraged to ask any questions regarding the consent form to ensure their understanding of the document. Each participant will be given a copy of the signed consent form for their records.

- d) Describe the protocol regarding record retention. Please indicate that research data from this study and consent forms will both be retained in separate locked locations for a minimum of three years following the completion of the study. Describe: 1) the storage location of the research data (separate from consent forms and subject personal data)
2) who will have access to the data
3) how the data will be destroyed
4) the storage location of consent forms and personal data (separate from research data)
5) how the consent forms will be destroyed

Participant consent forms and data collection sheets/computerized files will be stored separately and secured in separate locked locations in the Department of Physical Therapy. Only the investigators will have access to this information. After a period of 3 years from the completion of the study, the consent forms and data collection sheets will be shredded for final disposition and computerized data will be deleted from all disks/drives.

- e) Describe procedures to deal with adverse reactions (referrals to helping agencies, procedures for dealing with trauma, etc.). The investigators or participant may stop the experiment at any time if the participant is experiencing discomfort, pain, fatigue, or any other symptoms that may be detrimental to his/her health. If subjects consent to participate they will be allowed to terminate their participation in this study at any time without prejudice or jeopardizing any future relationships with the UND Department of Physical Therapy. All investigators are CPR trained. Medical treatment will be provided to each subject as needed, including first aid, CPR, and follow-up care as that provided to a member of the general public in a similar circumstance.
- f) Include an explanation of medical treatment available if injury or adverse reaction occurs and responsibility for costs involved.
In the event an adverse event occurs during participation in this study, the subject will be prompted to seek immediate medical attention. All incurred medical expenses will be the responsibility of the subject or the subject's third-party payer.

III. Benefits of the Study

Clearly describe the benefits to the subject and to society resulting from this study (such as learning experiences, services received, etc.). **Please note:** extra credit and/or payment are not benefits and should be listed in the Protocol Description section under Methodology.

Possible benefits of this study include but are not limited to: 1) gaining a better understanding of the muscle activity in the back muscles with trunk rotation and 2) increasing the current level of knowledge of muscle activity and motion patterns of these muscles during this activity; 3) further research may be stimulated; and 4) improved understanding of the kinematics of trunk rotation to aid in the teaching of this activity to students enrolled in the professional physical therapy curriculum. There will be neither cost associated with nor any compensation to any subject who participates in this study.

IV. Consent Form

Clearly describe the consent process below and be sure to include the following information in your description (Note: Simply stating 'see attached consent form' is not sufficient. The items listed below must be addressed on this form.):

- 1) The person who will conduct the consent interview
- 2) The person who will provide consent or permission
- 3) Any waiting period between informing the prospective participant and obtaining consent
- 4) Steps taken to minimize the possibility of coercion or undue influence
- 5) The language to be used by those obtaining consent
- 6) The language understood by the prospective participant or the legally authorized representative
- 7) The information to be communicated to the prospective participant or the legally authorized representative

1. The person who will conduct the consent interview will be the primary investigator or a second year PT graduate student. Consent interview will be done in a private location within the PT Department in the SMHS.
2. The person who will provide consent or permission will be the subject in the study. Only those subjects who understand written and verbal explanation of the test protocol in English and who are able to provide consent will be subjects in this study.
3. There will be no waiting period between informing the participant and obtaining consent.
4. All subjects will gain access to the study through voluntarily contacting the researcher for an opportunity to participate. During the consenting process, it will be explained to the potential subjects that the process is entirely voluntary and that they are free to withdraw at any point in the process. Withdrawal from the study will not alter their relationship with the Department of Physical Therapy in any way.
5. English will be the language used to obtain consent. Medical jargon will not be utilized to ensure subject understanding of the research protocol.
6. English will be the language understood by the participant.
7. All risks and benefits, test procedures, and consent document will be explained to each prospective subject.

See Attached form.

A copy of the consent form must be attached to this proposal. If no consent form is to be used, document the procedures to be used to protect human subjects, and complete the Application for Waiver or Alteration of Informed Consent Requirements. Refer to form IC 701-A, Informed Consent Checklist, and make sure that all the required elements are included. **Please note:** All records attained must be retained for a period of time sufficient to meet federal, state, and local regulations; sponsor requirements; and organizational policies. The consent form must be written in language that can easily be read by the subject population and any use of jargon or technical language should be avoided. **The consent form should be written at no higher than an 8th grade reading level**, and it is recommended that it be written in the third person (please see the example on the RD&C website). A two inch by two inch blank space must be left on the bottom of each page of the consent form for the IRB approval stamp.

Necessary attachments:

- ☐ Signed Student Consent to Release of Educational Record Form (students and medical residents only);
- ☐ Investigator Letter of Assurance of Compliance; (all researchers)
- ☐ Consent form, or Waiver or Alteration of Informed Consent Requirements (Form IC 702-B)
- ☐ Key Personnel Listing
- ☐ Surveys, interview questions, etc. (if applicable);
- ☐ Printed web screens (if survey is over the Internet); and
- ☐ Advertisements (flyer, social media postings, email/letters, etc.).

By signing below, you are verifying that the information provided in the Human Subjects Review Form and attached information is accurate and that the project will be completed as indicated.

Signatures:

(Principal Investigator)	Date:
(Student Advisor)	Date:

*****All students and medical residents must list a faculty member as a student advisor on the first page of the application and must have that person sign the application. *****

Requirements for submitting proposals:

Additional information can be found on the IRB website at: <http://und.edu/research/resources/human-subjects/index.cfm>

Original, signed proposals and all attachments, along with the necessary number of copies (see below), should be submitted to: Institutional Review Board, 264 Centennial Drive Stop 7134, Grand Forks, ND 58202-7134, or brought to Room 106, Twamley Hall.

Required Number of Copies:

- Expedited Review: Submit the signed original and 1 copy of the entire proposal.
- Full Board Review: Submit the signed original and 22 copies of the entire proposal by the deadline listed on the IRB website: <http://und.edu/research/resources/human-subjects/meeting-schedule.cfm>
- Clinical Medical Subcommittee and Full Board Review: Submit the signed original and 24 copies of the entire proposal by the deadline listed on the IRB website: <http://und.edu/research/resources/human-subjects/meeting-schedule.cfm>

Prior to receiving IRB approval, researchers must complete the required IRB human subjects' education. Please go to: <http://und.edu/research/resources/human-subjects/human-subject-education.cfm>

The criteria for determining what category your proposal will be reviewed under is listed on page 3 of the IRB Checklist. Your reviewer will assign a review category to your proposal. Should your protocol require full Board review, you will need to provide additional copies. Further information can be found on the IRB website regarding required copies and IRB review categories, or you may call the IRB office at 701 777-4279.

In cases where the proposed work is part of a proposal to a potential funding source, one copy of the completed proposal to the funding agency (agreement/contract if there is no proposal) must be attached to the completed Human Subjects Review Form if the proposal is non-clinical; 5 copies if the proposal is clinical-medical. If the proposed work is being conducted for a pharmaceutical company, 5 copies of the company's protocol must be provided.

**INVESTIGATOR LETTER OF ASSURANCE OF COMPLIANCE
WITH ALL APPLICABLE FEDERAL REGULATIONS FOR THE
PROTECTION OF THE RIGHTS OF HUMAN SUBJECTS**

I Susan H. N. Jeno
(Name of Investigator)

agree that, in conducting research under the approval of the University of North Dakota Institutional Review Board, I will fully comply and assume responsibility for the enforcement of compliance with all applicable federal regulations and University policies for the protection of the rights of human subjects engaged in research. Specific regulations include the Federal Common Rule for Protection of the Rights of Human Subjects 45 CFR 46. I will also assure compliance to the ethical principles set forth in the National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research document, The Belmont Report.

I understand the University's policies concerning research involving human subjects and agree to the following:

1. Should I wish to make changes in the approved protocol for this project, I will submit them for review PRIOR to initiating the changes. (A proposal may be changed without prior IRB approval where necessary to eliminate apparent immediate hazards to the subjects or others. However, the IRB must be notified in writing within 72 hours of any change, and IRB review is required at the next regularly scheduled meeting of the full IRB.)
2. If any problems involving human subjects occur, I will immediately notify the Chair of the IRB, or the IRB Coordinator.
3. I will cooperate with the UND IRB by submitting Research Project Review and Progress Reports in a timely manner.

I understand the failure to do so may result in the suspension or termination of proposed research and possible reporting to federal agencies.

Investigator Signature

Date

STUDENT RESEARCHERS: As of June 4, 1997 (based on the recommendation of UND Legal Counsel) the University of North Dakota IRB is unable to approve your project unless the following "Student Consent to Release of Educational Record" is signed and included with your IRB application.

STUDENT CONSENT TO RELEASE OF EDUCATIONAL RECORD¹

Pursuant to the Family Educational Rights and Privacy Act of 1974, I hereby consent to the Institutional Review Board's access to those portions of my educational record which involve research that I wish to conduct under the Board's auspices. I understand that the Board may need to review my study data based on a question from a participant or under a random audit. The title of the study to which this release pertains is EMG analysis of Latissimus Dorsi, Erector Spinae and Middle Trapezius Muscle Activity During Trunk Rotation.

I understand that such information concerning my educational record will not be released except on the condition that the Institutional Review Board will not permit any other party to have access to such information without my written consent. I also understand that this policy will be explained to those persons requesting any educational information and that this release will be kept with the study documentation.

ID #

Printed Name

Date

Signature of Student Researcher

¹Consent required by 20 U.S.C. 1232g.

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